Assessing The Role Of Small-Scale Bio-Optical And Bio-Acoustical Distributions In Upper Ocean Biological And Optical Processes

Timothy J. Cowles
College of Oceanic and Atmospheric Sciences
104 Oceanography Admin Bldg
Oregon State University
Corvallis, OR 97331-5503
Office: (541) 737-3966 FAX: (541) 737-2064 email: cowles@oce.orst.edu
Award # N00014-98-1-0094
http://www.onr.navy.mil/sci_tech/ocean/onrpgahj.htm

LONG-TERM GOALS

Our long-term goal is to quantify the interactions between small-scale biological and physical processes within the upper ocean. This project has addressed that goal by examining specific scientific questions which relate the distribution and variability in sub-1m scale bio-optical properties with coincident spatial scales of physical properties.

OBJECTIVES

Observations of persistent thin layers (20-40cm in thickness) of biological structure have raised many questions about the role of these features in upper ocean trophic dynamics, optical and acoustical signal propagation, and remote sensing. We do not yet understand the mechanisms that lead to the formation and maintenance of small-scale vertical structure in the upper ocean. This project addresses these issues through several specific objectives. First, we wish to define, in coastal environments under a range of forcing conditions, the small-scale structure of planktonic organisms, as identified through measurements of spectral light absorption, attenuation, light scattering, and spectral fluorescence. Those optical measurements have coincident measurements of the small-scale vertical structure in downwelling spectral irradiance, upwelling radiance, temperature, salinity, and density. Second, we wish to quantify the role of physical processes such as internal waves and small-scale vertical shear in horizontal velocity on the persistence of plankton layers. In collaboration with other ONR investigators in the East Sound Thin Layers experiments, we are investigating the interaction between the vertical scales of distribution of dissolved organic compounds (as detected with in situ optical sensors) and those optical properties relevant to remote sensing (absorption and reflectance).

APPROACH

Our scientific objective has been to obtain time series profiles which document the vertical patterns of bio-optical distribution and variability in several coastal oceanic habitats. We have accomplished this objective by integrating newly developed bio-optical instrumentation with a CTD into a free-fall package that resolves physical, optical, and biological features over small vertical scales. The instrumentation package has an adjustable fall speed so that we can resolve

Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE
1998

2. REPORT TYPE

3. DATES COVERED
00-00-1998 to 00-00-1998

4. TITLE AND SUBTITLE
Assessing The Role Of Small-Scale Bio-Optical And Bio-Acoustical Distributions In Upper Ocean Biological And Optical Processes

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
Oregon State University,College of Oceanic and Atmospheric Sciences,104 Oceanography Admin Bldg,Corvallis,OR,97331-5503

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSOR/MONITOR’S ACRONYM(S)

11. SPONSOR/MONITOR’S REPORT NUMBER(S)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
See also ADM002252.

14. ABSTRACT

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Same as Report (SAR)**	**4**	

vertical patterns on scales less than 10 cm. Typically, we adjust the buoyancy on the profiling package to provide 2-3 cm resolution of physical and bio-optical properties during each profile. Repeated profiles (approximately 10 per hour) provide the time series necessary to define the temporal patterns of persistence of small-scale features. The profiling package is designed so that the instrumentation configuration can be modified easily. During our work in East Sound in 1998, the deployment configuration consisted of a Sea-Bird 911 CTD, dual multi-wavelength absorption and attenuation meters (ac-9), a multi-wavelength spectrofluorometer which measures dissolved colored organic matter (SAFIRE), a data acquisition system (MODAPS), an Acoustic Doppler Velocimeter (ADV), and a rosette system for obtaining discrete samples during profiling (Figure 1).

***Figure 1. Free-fall profiling system used during East Sound Thin Layers experiment. Note the rosette and small bottles at the base of the profiler*.**

WORK COMPLETED

We completed an extensive collaborative field experiment in East Sound, Orcas Island, WA, during May and June 1998. We obtained over 400 profiles of small-scale bio-optical and physical structure under a range of forcing conditions. We applied our data merging protocols for multiple instruments on the profiling package (each instrument has a unique data acquisition rate) to obtain coincident physical and bio-optical data on the appropriate vertical scale. We recovered a thermistor chain that had been deployed for two weeks, providing resolution of physical forcing through internal wave energy. In addition, we monitored spectral upwelling radiance and spectral downwelling irradiance throughout the day with a tethered radiometric buoy.

RESULTS

We observed several types of small-scale structure in bio-optical properties during our 1998 experiment

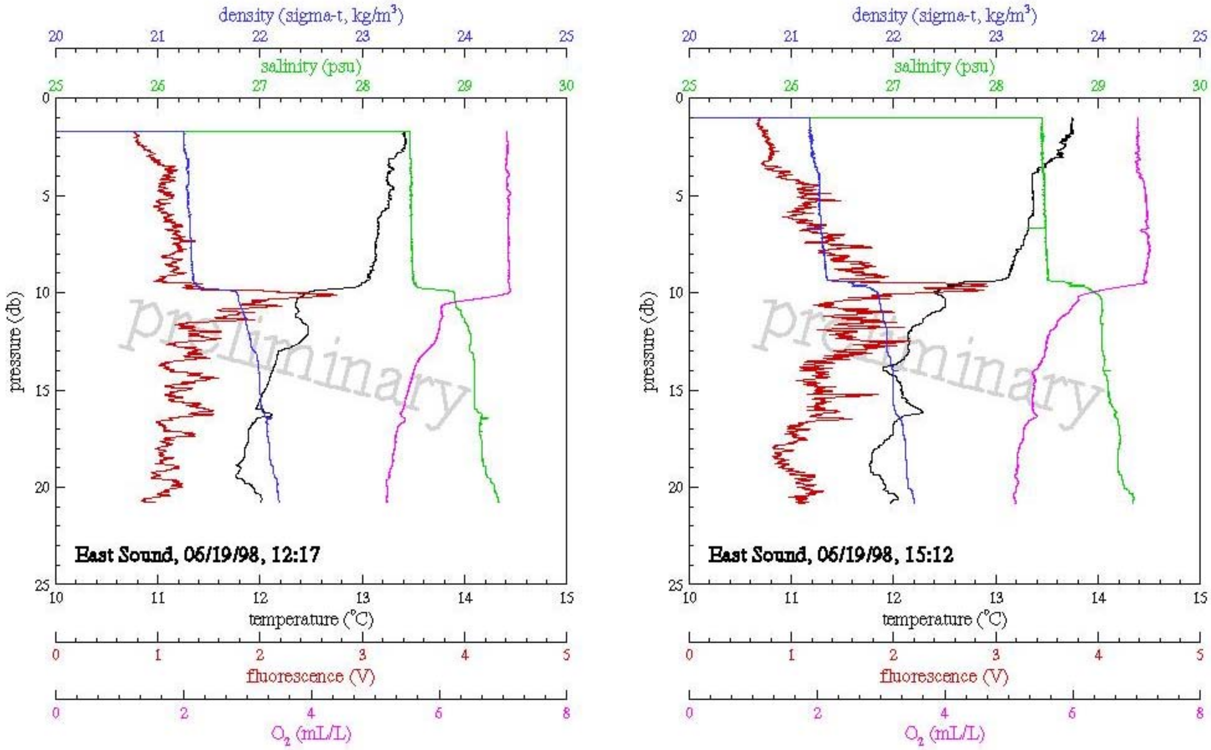

Figure 2. High-resolution profiles obtained with the free-fall profiler (see Figure 1) on June 19, 1998 in East Sound, WA. Note the thin fluorescence feature at the base of the mixed layer.

in East Sound. We saw thin layers of phytoplankon that persisted for several hours, as illustrated in Figure 2. We also observed many instances of several-fold changes in properties over vertical scales of 20-40 cm. We are in the midst of data processing and analysis of our extensive data set.

IMPACT/APPLICATION

Our results suggest that additional direct assessment of the trophic implications of persistent thin layers is needed, with particular emphasis on the potential for enhanced grazing, steeper local gradients in nutrient flux and regeneration, and variations in particle flux from the euphotic zone. Our work with biological microstructure suggests that previous observations of small-scale biological patchiness may not have been observations of stochastic fluctuations in biological structure (i.e., patchiness), but under-sampled observations of persistent, small-scale structure. Centimeter-scale organization of planktonic biomass forces a re-evaluation of water column rate processes, and challenges our existing paradigms for sampling and experimentation over scales of meters and 10's of meters.

TRANSITIONS

We are making the transition from observations of small-scale pattern to analysis of the mechanisms which create that persistent pattern. This will be essential for prediction of the

impact of persistent small-scale pattern on the attenuation of optical and acoustic signals in the upper ocean.

RELATED PROJECTS

Our ongoing work has led to direct field collaborations with the following ONR Principal Investigators:

Dr. Percy Donaghay, University of Rhode Island
Dr. Jan Rines, University of Rhode Island
Dr. Dian Gifford, University of Rhode Island
Dr. Alice Alldredge, UC Santa Barbara
Dr. Sally MacIntyre, UC Santa Barbara
Dr. Mary Jane Perry, University of Washington
Dr. Van Holliday, Tracor Systems